(19) Japan Patent Office (JP) (12)Public Patent Journal (A) (11) Publication Number 8-209299

(43) Publication Date: 08-13-1996

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(51) International Classification: C22C 38/00 C22C 38/00 B21B 27/00 C22C 33/02 C22C/ 38/46 C22C 38/58

(54) [Name of the Invention] High heat resistant roll material and the making method

(57) Abstract

(Purpose) The present invention is to provide a heat and cracking resistant alloy for hot rolling mill roll used in working temperature above 850 C.

(Constitution): The chemical composition of the invention is as follows (by weight %); C: 2.0-4.0%, Si: 1.0-5.0%, Mn 0.1-2.0%, Cr: 0.1-6.0%, Mo: 0.1-6.0%, V: 0.1-6.0%, Ni:1.0-8.0%, this alloy also contains, if necessary, W: 0.1-6.0%, Nb: 0.1-4.0%, Co: 0.1-10%, the balance is iron with other inevitable impurities. A portion of silicon is added as inoculation to promote the formation and precipitation of graphite to improve seizure resistance of the rolling mill roll alloy.

[Patent Requested Ranges]

[Claim 1] Chemical composition by weight %

C: 2.0—4.0%, Si: 1.0—5.0%, Mn: 0.1—2.0%, Cr: 0.1—6.0%,

Mo: 0.1—6.0%, V:0.1-6.0%, Ni: 1.0—8.0%, the balance is iron and other inevitable impurities. A heat resistant material used for hot rolling roll.

[Claim 2] Based on claim 1, 0.1-2.0 % silicon is added as inoculant within silicon content range.

[Claim 3] Based on claim 1, the alloy at least contains 0.1-6.0%, 0.1-4.0% Ni, 0.1-10.0% Co. A heat resistant alloy used for making hot rolling roll that contains at least one of the W, Ni, and Co elements in claim 1.

[Claim 4] A method to make a high heat resistant hot rolling roll based on claim 3, 0.1-2.0% silicon is used as inoculant.

[Detailed Description of the Invention]

[0001]

[Industrial Application]

The present invention is about high heat resistant materials for making various hot rolling rolls and its manufacturing method.

[0002]

[Prior Art] Recent years, the requirement for wear resistance, cracking resistance, and oxidation resistance of the roll materials is getting higher and higher as the rolling speed and load increase, especially for rolls working in the later rolling process where accident and oxidation are common.

[0003] Ni-Cr alloy is used as hot rolling roll material in the past. Japan Patent 2-88745 discloses a high chromium cast iron roll and roll materials from high speed steel containing Mo, Co, W, and V with excellent wear resistance. Recent years, compared to Ni-Cr type roll alloys, high speed steel type cast irons with better wear, oxidation, cracking, and thermal shock resistance have been widely used for making rolling rolls.

[0004]

High speed steel type cast iron roll material has excellent wear resistance because of it high hardness precipitated carbides. For example, breaking and oxidation are common problems in the later sections of hot rolling mill when the rolled material temperature is above 850 C, which causes a lower productivity and efficiency with the raised cost. Oxidation resistance can be improved in many ways.

[0005]

[Problems to be solved] The present invention provides a better wear, cracking, thermal shock and heat resistant material for hot rolling roll and the method of making it, especially for hot rolling rolls working at above 850 C.

[0006]

[Methods to solve the problems] The first example of the invention (by weight percent)
C: 2.0—4.0%, Si: 1.0—5.0%, Mn: 0.1—2.0%, Cr: 0.1—6.0%, Mo: 0.1—6.0%, V:0.1-6.0%,
Ni: 1.0—8.0%, the balance is iron with other inevitably impurities.

[0007] The second invention is based on the first on by using 0.1-2.0% silicon as inoculant to make high heat resistant hot rolling mill roll.

[0008] The third invention further contains one of the three elements from 0.1-6.0 % W, 0.1-4.0% Ni, and 0.1-10.0% Co based on chemical composition in the first invention.

[0009] The fourth invention contains 0.1-2.0% silicon where silicon is added as inoculant based on chemical composition in the third invention.

[0010]

[Advantages of the invention] To achieve excellent heat resistance, the present invention is based on high speed steel type cast iron to increase silicon content properly and to add nickel as a necessary element to promote formation of graphite. Cr, Mo, and V ,as well as W, Nb, and W, can be used properly to increase wear resistance.

[0011] Compared to previous high manganese steel type cast iron the present invention has a better heat resistance with similar wear, cracking, and thermal shock resistance to high manganese steel, especially suitable for making hot rolling mill rolls used in high temperature.

[0012] As described before, it is well known that high manganese steel type cast iron with precipitated Mo, Cr, W, and V carbides can be used for making rolling mill roll.

[0013] However, these high manganese steel type cast iron rolls do not have enough oxidation resistance though excellent in wear, cracking, and thermal shock resistance. The cost of these rolls is higher because of expensive alloy elements used in threes alloys. The inventors have done experiment to confirm the above points, and therefore develop a new rolling mill roll material with better oxidation resistance while still having excellent wear, cracking, and thermal shock resistance.

[0014]The following is a detailed description of the invention. Graphite is precipitated in a proper amount in the present invention of heat resistant rolling mill roll material. The formation of graphite can stop oxidation propagation in the matrix to improve its heat resistance.

[0015]

(1) Carbon is between 2.0-4.0%, carbon promotes graphite precipitation and also forms high hardness MC, $M_2C$, $M_6C$ $M_7C_3$ type alloy carbides with Cr, Mo, V to increase wear resistance. Therefore the carbon content is higher than that in the well known high manganese steel type roll material. Graphite precipitation will not be enough and improvement in heat resistance will be limited when carbon is less than 2.0 %. On the other hand, when carbon is higher than 4.0 %, too much carbide will be formed, resulting in a poor toughness and thermal shock resistance.

[0016] (2) Silicon content is between 1.0-5.0%. Silicon is normally in 0.3-2.0% to obtain a good fluidity. Silicon is higher in order to promote graphite to precipitate from matrix. It is difficult to form graphite if carbon is less than 1.0 %; However castability will deteriorate when silicon is greater than 5.0%.

Put 0.1-2.0% silicon (1/10-2/5 of total silicon content) during inoculation to further promote graphite precipitation.

[0017](3) Manganese content is between 0.1-2.0%. Manganese can remove oxygen and sulfur as well as improving hardening ability.

[0018] (4) Chromium content is between 0.1-6.0%. Chromium can form carbide to improve wear resistance. Chromium in the matrix increases quenching ability. Chromium higher than 6.0% will restrict graphite precipitation and also limit further improvement in oxidation resistance.

[0019] (5) Molybdenum is between 0.1-6.0%. Molybdenum can form M2C type carbide, and some molybdenum can enter matrix in the solid solution form to improve quenching ability and also achieve secondary hardening in tempering process. No significant improvement in wear resistance and high temperature hardness if molybdenum is less than 0.1%; Molybdenum will retard graphite precipitation if higher than 6.0%.

[0020] (6) Vanadium is between 0.1-6.0%, Vanadium forms vanadium carbide to increase wear resistance. The vanadium carbide is not enough and therefore no significant improvement in wear resistance if vanadium is less than 0.1%;

[0021] (7) Nb can partially or totally replace V. The amount of Nb should not be greater than 4.0%. MC carbides in primary dendrites increases when Nb is higher than 4.0 %, which will result in a lower crack resistance and a poor roll surface finish.

[0022] (8) Ni is between 1.0-8.0%, Ni can promote graphite precipitation in the alloy. Graphite precipitation will not be enough if Ni is less than 0.1%. Quenching ability will become too sensitive and therefore resulting in a poor hardening ability when Ni is higher than 8.0%.

[0023] (9) W is between 0.1-6.0%. W can increase wear resistance by forming tungsten carbide. There is no obvious improvement in wear resistance when W is less than 0.1% because there is not enough tungsten carbide formed; on the other hand, W will prohibit graphite precipitation causing no improvement in heat resistance when W is higher than 8.0%.

[0024](10) Co is between 0.1-10%. Co can improve high temperature strength of the matrix. There is no obvious effect when Co is less than 0.1% while Co will deteriorate toughness of the alloy when Co is greater than 10%.

[0025] Although the heat resistant roll material in the present invention can be cast and then machined into rolling roll with the same material, the high hardness of the material is Hs 75-95 after heat treatment. It is a good way to make composite roll with high toughness inner layer material in order to keep high wear resistance and high strength at the same time. The present invention can be used as an external layer material.

[0026] [Examples] There are well know chromium series and high manganese steels type cast iron for making rolling roll materials. Comparative samples are made from these materials for heat resistance test.

[0027] Experimental setup for heat resistance test is shown in Fig. 1. 1 is the rolling mill roll sample heating furnace. 2 is the heating element and 3 is an electric motor used to drive the sample stage 4. There is a vertical up and down mechanism 5 above the stage, sample holder 6 and cylinder 7, 8 is a computer for data acquisition.

[0028] In the heat resistance testing set-up, set the desired temperature in furnace 1. The sample is fastened on the sample stage, rotate the stage and then move the sample up and down periodically. Record the number of up and down times before the sample begins to oxidize. The higher the number the better the heat resistance of the material is.

[0029] Use the heat resistance set-up to test all sample alloys in table 1. The results are given in table 2.
[0030] [Table 1]

[0032] The experimental conditions are listed below;

Heating element plate (S45C)
Temperature: 1100 C
Rolling roll sample temperature: room temperature
Amount of compression of the rolling roll sample: 0.1mm/each test
Rotating speed of the heating element plate: 100 rpm
Contact time between rolling roll sample and the heating element plate: 0.2 second/each

As shown in table 2, the critical number of contact before oxidation is greater than 17 times, 4 times higher than that of Ni-Cr rolling mill roll material and 3 times higher than high chromium steel type rolling mill roll material. Heat resistance has been significantly improved.

[0033] Rolling mill roll material samples B and D with silicon inoculant have a higher number of contact times than that with regular silicon addition.

[0034] The excellent wear and thermal shock resistance have been confirmed by the well known experimental methods.

[0035] Comparative samples having major elements C, Si, Cr, Mo, Ni, V out off the present ranges show a critical contact times between 9-14 times. Compared to high speed type cast iron roll material, the heat resistance of the comparative samples exhibits some improvement. However, the heat resistance of these materials is not adequate for hot rolling roll working in 850-1000 °C.

[0036]As stated above, the heat resistance of the present invention is much better than high speed steel type roll materials while wear, cracking, and thermal shock resistance are similar to the high speed steel type cast irons. The present invention is especially useful for making hot rolling rolls working at 850-1000 C, which will extend the service life of the rolls, improve the rolled product quality, and increase productivity.

[0037] The present inventive heat resistant roll material can also be used in other sections of rolling process for different shapes of steels.

[0038][The principle of the invention] The present invention is based on the composition of high speed steel type cast iron roll material with properly raised carbon and silicon to promote graphite precipitation by using nickel. Because of the use of Cr, Mo, and V, the wear and cracking resistance have been improved with the proper addition of W, Nb, and Co.

[0039]The heat resistance of the present invention is much better than high speed steel type roll materials while wear, cracking, and thermal shock resistance are similar to the high speed steel type cast irons. The present invention is especially useful for making hot rolling rolls working at 850-1000 C, which will extend the service life of the rolls, , reduce the roll unit wear rate, improve the rolled product quality, and increase productivity.

[Description of the drawings] Fig. 1 is the side view of the oxidation experimental setup

[legend] 1 heating furnace, 2 heating element plate,….